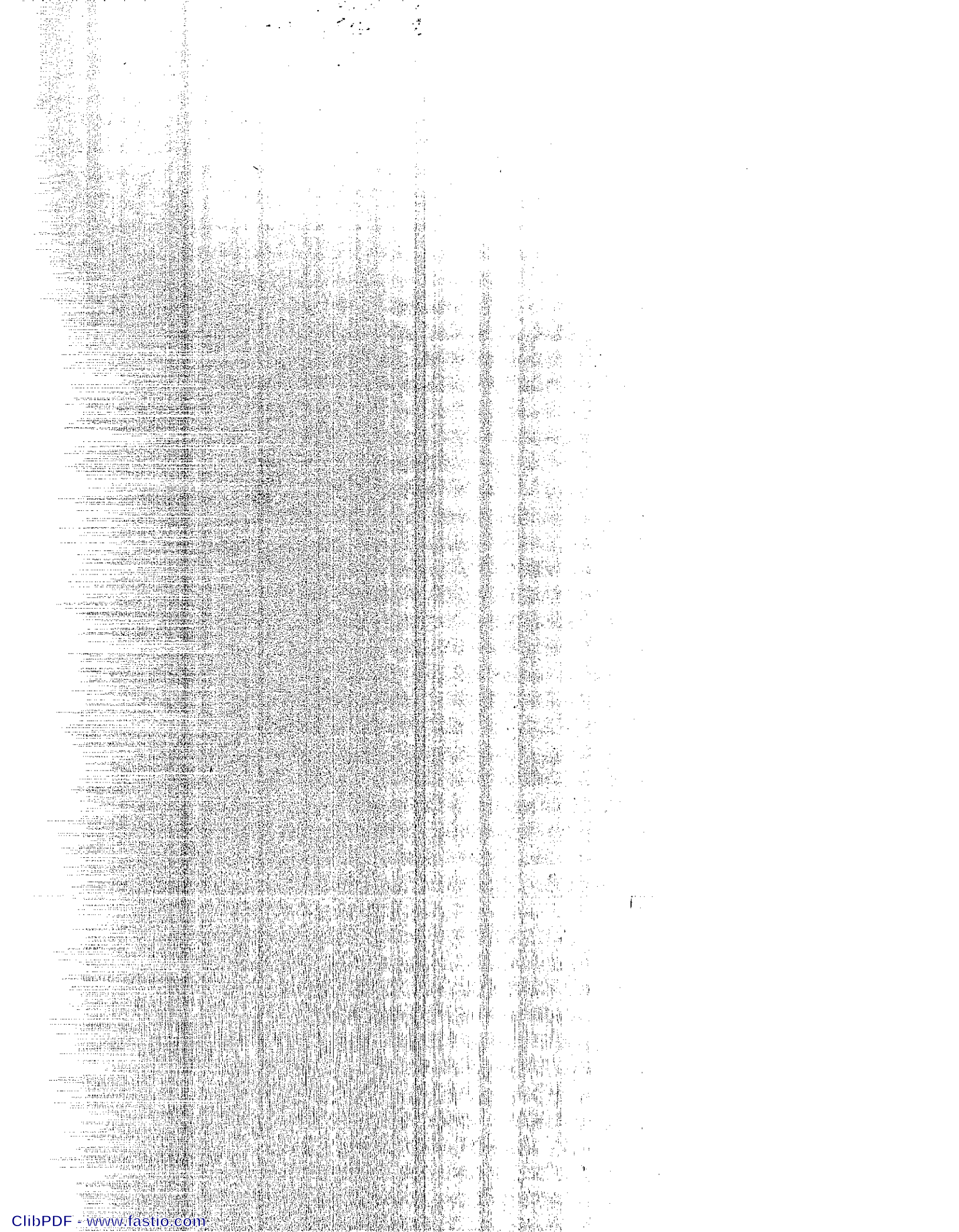

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CALIFORNIA'S EXPERIENCE WITH RAISED TRAFFIC LANE MARKERS

By

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In December of 1965 the California Division of Highways adopted a policy that raised pavement markers would be used in lieu of painted lane lines on all future multilane freeways, expressways, and two-lane rural highways in areas that do not involve snow removal. They were to be included in all future projects, and as feasible, change orders were issued to cover all projects under way at that time. In addition, a limited funding has been available each year so as to install markers on existing roads with the highest priority.

The lane line adopted consists of four non-reflective white markers at 3 foot centers with a 15 foot gap between the sets of four, supplemented with one reflex reflector on 48 foot centers on tangents and 24 foot centers on curves. The reflex reflectors were placed in the center of the 15 foot gap between the cluster of non-reflective markers. They showed a clear night-time reflection to traffic travelling in the correct direction, and red in the wrong direction. Later the use of yellow reflective and non-reflective markers was adopted to supplement or replace the yellow striping.

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The adoption of this practice followed some 12 years of concentrated research and development of raised traffic line markers. Actually, we first started experimental use of raised markers in 1936, but unfortunately, the only positive means of fastening the units to the pavement was by the use of long spikes. This presented a traffic hazard when the marker broke loose, so research was abandoned.

In 1953 we became interested in the adaptation of the new epoxy adhesives to highway construction and maintenance. Since we had learned through experimentation that such adhesives had excellent all-weather properties, and good bonding strength to both portland cement and asphaltic concrete pavements, we decided to revitalize our marker program. During the next 12 years, we developed markers of various formulations, each pigmented white with titanium dioxide and containing modified epoxy resins as a binder. Sand and glass bead fillers were used. Another type marker containing white portland cement as a binder in lieu of epoxy resins was also tried with success on rigid pavements. The earliest adhesive we used to cement the markers to the road surface was an epoxy-polysulfide system.

Towards the end of the experimental phase, we became aware of the use in Texas of ceramic non-reflective markers, and included them in our program also. During the experimental period we placed with our own forces, slightly more than 100 miles of traffic "buttons" as they were first called. We found that any of the various types of white reflective markers having either an epoxy or polyester binder and made reflective with glass beads,

when properly glued to the surface could be expected to give a service life of approximately 20 years on a portland cement concrete surface, and 10 on an asphalt surface. This was also true of the non-reflective type which were similar but without glass beads.

We had considered the first phase of our research work completed in 1964 and had decided to use raised traffic buttons to replace the painted lane line, utilizing a combination of glass bead reflective markers and non-reflective markers so as to provide a day and night lane line. However, about this time the reflex reflective raised marker encapsulated in an acrylic case was placed on the market, so we conducted an accelerated study to determine whether or not such markers were compatible with our adhesives, and also to determine the service life we might expect. We found the reflex reflective marker to be compatible with our adhesives, and from a one-year study, anticipated that we could expect a service life of about three years on a heavily travelled freeway, and about five years on a moderately travelled road. Even with this relatively short life, it was decided that the superior reflection offered by the reflex reflector should be used to create our night-time lane line. Since the introduction of the acrylic cased reflector, a similar unit encased in ABS plastic has been introduced, which is equally acceptable.

Our experience since adopting the raised marker program in 1965 can be roughly divided in two areas, construction and maintenance. The problems, and our solution in each of these areas are outlined below.

Construction:

The use of epoxy resins and the placement of markers was found to require a more sophisticated control procedure than was normal in ordinary highway construction. In addition to this, when we first started the program, there were very few experienced contractors in the business. Unfortunately, specialty contractors could enter the field having relatively a small capital investment. This combination of inexperience in both the contractor's forces and our inspection staffs, led to many problems during the first year. This was somewhat complicated by the borderline financing of many of the companies. The hard facts of competition have now pretty well solved the financial problems, and training and experience have solved the first problem. Our study of the problems which occurred in the field led to an on-the-spot training of field inspectors and the issuance of the following guide to be used in the control of such work.

CONSTRUCTION GUIDE

Recommended preliminary preparation and general information for the inspector:

1. Place a marker over a road surface similar to the job in question using hand mixed adhesive and become familiar with the rate of set of the adhesive and the hardness of the excess adhesive around the marker. (A thin piece of paper over the road surface will permit removal of the marker.)

2. Prepare fresh color standard of hand mixed adhesive exactly for each batch of material for use in judging contractor's mix.

3. Become familiar with the extrusion equipment and the installer's technique, and determine how best any signs of inadequate mixing or proportioning can be determined during application. Inadequate mixing may show up as fine streaks or in layers which would occur if one component is partially channeled through the mixing head. (This has been observed most frequently with the "B" component.)

Inadequate proportioning will be indicated by a color change. Both inadequate mixing and proportioning can occur simultaneously.

4. Epoxy mix extruded onto a cardboard will permit more careful examination of the metering and mixing. These samples could also be examined when partly set by cutting or when completely set by fracturing a cold sample with a bolt cutter or cold chisel. Ten or twenty samples/mile would be reasonable in some cases where quality is in doubt. The samples must be taken by the Engineer.

5. Verify that the equipment is metering the components 1:1 ± 5% by volume at the beginning of each day or at any time when a check is desired.

"TROUBLE SHOOTING" MARKER INSTALLATION PROBLEMS

Observation	Probable Cause	Remedy
Epoxy "off" color (See Note 1)	Improper proportions of components	Adjust mixing equipment to meter epoxy components 1:1(±5%) by volume.(See Note 2)
Color not uniform. Streaks of black and/or white and/or gray	Inadequate mixing of components	Adjust mixing head to obtain complete mixing. (See Note 2)
Layers or pockets of one component (generally hardener) in mixed epoxy	Channeling of component through mixing head	Adjust mixing head to obtain complete mixing (See Note 2)
Absence of slight excess of epoxy around all edges	1. Insufficient amount of epoxy 2. Marker not properly applied	1. Adjust equipment to meter adequate amount.(See Note 2) 2. Be certain that markers are firmly pressed down on road surface to assure complete contact. (See Note 3)
Markers slip on grade	Marker not properly applied	Same as "2" above
Epoxy on upper surface of marker	Sloppy application	If still uncured, epoxy may be removed with kerosene (See Note 4). If cured, marker should be removed and replaced.

Note 1. Prepare a color standard for each batch of epoxy adhesive by thoroughly mixing equal volumes of the two components. Only a small amount, i.e., 1/2 pint or less, need be mixed. This standard may be used in either the uncured or hardened states.

Note 2. If the mixing equipment cannot be adjusted or cleaned to obtain the desired results, it should be considered defective, and should be repaired or replaced. Slowing rate of delivery of epoxy, not mixer RPM, may improve mixing.

Note 3. Markers should not be applied over cracks or joints or over materials such as asphalt slurry seal, traffic paint, or thermoplastic traffic paint. The road surface should be prepared by sandblasting (or other suitable methods).

Note 4. No other solvent should be used for this purpose as it may damage the plastic surfaces of the reflective markers.

GENERAL INFORMATION ON FIELD INSPECTION

An inspector not completely familiar with marker installations can improve the quality of inspection by watching for any condition which indicates non-uniformity in the metering and mixing operations, or in general workmanship.

The color of the color standards should be the same as that of the extruded adhesive. In case of doubt, remake color standards from the tanks from the mixing machine. Color checks can be made after installation, but checks during installation are preferable.

The rate of set will be faster at higher temperatures, but the speed of set of the adhesive will have a uniform rate of increase or decrease as the temperature changes.

The hardness of the epoxy around the marker as determined by indentation (fingernail, screw driver, Shore D durometer, etc.) should also be uniform for the same length of cure at the same temperature. Sometimes this may be the only test that can be made if an inspector cannot be on the job continuously during placement of markers. If this test is used, it is recommended that a marker be placed on the roadway with hand mixed material at 1 hour or 2 hour intervals in the area where the contractor is working. Then when the test for indentation is made, a "reference" sample will be available. In addition to checking the hardness of the rim of epoxy around the marker, a tool could be used to pry up or laterally displace the marker on portland cement concrete

only. This test would be valuable in picking our markers where channeling had occurred, and the epoxy was soft under the marker, but the ridge was fairly hard. This should only be used when all properly mixed adhesive was well set and these markers would not be disturbed. Any marker displaced to any degree must be replaced as the bond will be damaged.

All workmanship in placing markers must be carefully inspected. (1) the marker must be completely supported with adhesive and the marker must be forced into contact with the road surface, (2) excess adhesive must be removed from the marker surface, (3) asphalt slurry seal, traffic paint, or thermoplastic traffic paint will not hold markers, and (4) markers must not be placed over joints, and the surface must be sandblast cleaned.

Maintenance:

The first step in our maintenance program was to send a team from the laboratory to all of the districts so as to instruct the maintenance forces in proper procedures to follow in their replacement program. Two major problems developed during usage of the markers. First, due to maintenance need for immediate traffic usage, the adhesive being used for contract work was found to be too slow in set time. It was therefore necessary that we develop a rapid set adhesive and train the maintenance forces in its proper use. This has been done. This type of adhesive is also used on contracts which place markers in traffic.

The second problem concerned blackening of the markers by a combination of traffic exhaust emissions and ground rubber. In California's hot dry summer this is particularly bad in that it covers the markers with a thin black film. It was found that the plastic type of non-reflective marker blackened more quickly than the ceramic type, apparently because the ceramic surface lent itself better to cleaning by tire traffic. It is interesting to note that a very brief rain will remove this material from the

marker. Our first corrective move in this direction was to require that ceramic buttons only be used in our hot, dry areas, and our second was to initiate the development of a cleaning device. At present we are also studying the use of tempered glass as a further improvement of the non-reflective marker.

We have also made a special study of methods to protect or clean the markers during oiling and sanding operations. So far as cleaning materials are concerned, we found solvents containing aromatics or ketones should not be used since they damage the shell of the reflective markers, and impair their reflectivity. We did find that kerosene can be used to clean either acrylic or ABS provided the cleaning is done promptly. Insofar as protecting the markers by covering is concerned, we tried many systems, such as using portland cement slurry, sand cover, water soluble glue paper tape, anti-friction and mold release agents and a brush-on waxy silicone release agent. All were successful to a degree except the anti-friction and mold release agents. However, the procedure that seems to work best is to leave an untreated 8-inch strip between the lanes so as to miss the markers, followed up by kerosene cleaning of any that were inadvertently hit.

It is interesting to note that so far, our use of raised traffic line markers seems to indicate that the originally estimated service lives are approximately correct. In conclusion, the important considerations in placing raised markers are (1) a sand blasted clean pavement surface, (2) a properly mixed epoxy adhesive, (3) contact between the marker and pavement surface, and (4) sufficient cure time before use.